

Asteroid 2007 WD₅ will not impact Mars on January 30!

by

Małgorzata Królikowska and Grzegorz Sitarski

Space Research Centre, Polish Academy of Sciences,
Bartycka 18A, 00-716 Warsaw, Poland
e-mail: mkr@cbk.waw.pl; sitarski@cbk.waw.pl

A B S T R A C T

The Monte Carlo method of the nominal orbit cloning was applied to the case of 2007 WD₅, the asteroid from the Apollo group. Calculations based on 33 observations from the time interval of 2007 11 08 - 2008 01 02 showed that the asteroid will pass near planet Mars at the minimum distance of $10.9 \pm 2.9 R_{\text{Mars}}$, what implies that probability that 2007 WD₅ strike the planet decreased to the value of 0.03% from the value of about 3–4% previously announced by NASA. The additional observations taken on January 3–9 reduce further the asteroid's impact chances, effectively to nil: the asteroid will pass near planet Mars at the minimum distance of $8.4 \pm 1.1 R_{\text{Mars}}$.

1. Introduction

The asteroid, known as 2007 WD₅, was discovered on November 20, 2007 by Boattini of the NASA-funded Catalina Sky Survey on Mount Lemmon, near Tucson (Arizona, USA) using a 1.5 m telescope. The size of asteroid was estimated as ~ 50 m.

Next day, Chesley and Chodas (2007) from the NASA/JPL Near-Earth Object Program Office announced that newly discovered asteroid which passed close to the Earth in November, will pass very close to Mars in late January, and there is a chance that it could hit that planet.

On December 28, 2007, Yeomans et al. (2007) informed on Web page that three pre-discovery observations of asteroid, taken on November 8, 2007 were located by Puckett in the archive of the Sloan Digital Sky Survey II at the Apache Point Observatory. They refined the orbit of 2007 WD₅ and found that the probability of Mars impact on January 30, 2008 increased to 4%, whereas the uncertainty region of the asteroid position during the Mars encounter has shrunk to 400 000 km along a very narrow ellipsoid. They stressed that the uncertainty region of the asteroid position during the Mars encounter could shrink more – to the region which will no longer intersect with the planet surface.

The last (at the moment of writing this text) report from NASA/JPL (Chesley et al. 2008) – based on the additional observations of the asteroid between Dec. 29 and Jan. 9 – significantly diminished the asteroid chances to strike Mars to approximately 0.01%. Chesley et al. (2008) estimated that asteroid 2007 WD₅ most likely will pass about 8 Mars radii, $r_{\text{Mars}} = 8 R_{\text{Mars}}$, from the planet's center on Jan. 30 and with 99.7% confidence, the asteroid should be no closer than $1.2 R_{\text{Mars}}$ from the planet's surface.

According to NeoDys (2008) calculations based on the observation arc from 2007 11 08

to 2008 01 09 the asteroid will pass near Mars at the nominal distance of $2.204 \cdot 10^{-4}$ AU ($9.7 R_{\text{Mars}}$), whereas the minimum possible distance is $8.815 \cdot 10^{-5}$ AU ($3.9 R_{\text{Mars}}$). These estimates suggest that asteroid 2007 WD₅ will pass Mars even in the greater distance than was suggested by Chesley et al. (2008).

The aim of this note is to present how our method of the nominal orbit cloning allows to determine the set of impact orbits as well as the probability of this impact for the case of 2007 WD₅.

2. The method

The present investigations are based on the archive positional observations taken from the NeoDys (Near Earth Object - Dynamic Site, University of Pisa, Italy) publicly available on the Web at

<http://newton.dm.unipi.it/neodys/mpcobs/2007WD5.rwo>. The whole observational material contains 46 observations covering the time period from November 8, 2007 to January 9, 2008.

The equations of asteroids motion have been integrated numerically using the recurrent power series method (Sitarski (1989), (2002)), taking into account the perturbations by all the nine planets and by the Moon. The planetary coordinates were taken from the Warsaw numerical ephemeris DE405/WAW of the Solar System, consistent with a high accuracy with the JPL ephemeris DE405 (Sitarski 2002).

We derived the nominal orbits using the least squares orbit determination method for four different sets of residuals given in the second column of Table 1. The respective solutions are denoted as A, B, C, and D, where solutions B and C differ only in a number of residuals taken into account for the orbit fitting: three residuals of significantly larger values in comparison to the rest of data were excluded in the case C. The nominal rms's are given in column 4 of Table 1.

The sample of 10 000 clones of each nominal orbit was selected randomly according to the normal distribution in the 6D-space of orbital elements (the method is described in details by Sitarski (1998)). In the column 5 of Table 1 upper limits for the rms of the true (but unknown) orbit are given for the confidence level of 99%.

The orbit clones from the samples A–D were integrated forwards up to the close encounter with Mars on January 30.

2. Results

We obtained 220 impact orbits for the Mars encounter on January 30, 2008 by numerical integrations of 10 000 orbital clones in case A. The distribution of minimum asteroid distance from Mars are presented for the solution A by black histogram in Fig. 1. Thus, the impact probability of $2.2 \cdot 10^{-2}$ was calculated for this arc of observations. However, the refinement

Table 1: Description of four orbital solutions for 2007 WD₅ and the derived minimum distance for asteroid close encounter with Mars on January 30, 2008. To estimate the value of rms_{true} (column 5) the confidence level of 99% was assumed.

Solution	Observational interval	Number of res.	Mean res.	rms_{true} not greater than	Minimum distance [R_{Mars}]	Impact probability [%]
A	2007 11 08 – 2007 12 31	64	0''521	0''585	11.9 ± 5.9	2.2
B	2007 11 08 – 2008 01 02	68	0''512	0''572	13.0 ± 4.6	0.4
C	2007 11 08 – 2008 01 02	65	0''308	0''346	10.9 ± 2.9	~ 0.03
D	2007 11 20 – 2008 01 09	89	0''268	0''293	8.4 ± 1.1	~ 0.0

of the asteroid's orbit using also the observations taken on January 2 significantly reduces the chance of impact on Mars. Cyan, blue and magenta histograms in Fig. 1 represent the distribution of minimum asteroid distance from Mars for solutions B, C and D, respectively. One can see, that for the solution C the impact probability decreases to the value of $3 \cdot 10^{-4}$ (we found three impact orbits among the sample of 10 000 clones), and for the case D – the impact seems to be impossible.

Gaussian distribution of r_{Mars} and the impact probability are given in the columns 6 and 7 of Table 1 and in Fig. 1. Projections of the 6D ellipsoid of orbital elements onto the a-e plane for the solutions A–D are shown by red points in Fig. 2– 3. The shrinking of the uncertainty ellipsoid with the refinement of 2007 WD₅ nominal orbit and its moving away from the impact region are clearly visible. For the longest arc of observations (case D) the asteroid will pass near planet Mars at the minimum distance of $8.4 \pm 1.1 R_{\text{Mars}}$ (magenta distribution in Fig 1) what implies that with 99.7% confidence, the asteroid should be no closer than $4.1 R_{\text{Mars}}$ from the planet's surface.

Thus, our calculations indicate that the possibility of asteroid 2007 WD₅ collision with Mars seems to be ruled out.

Acknowledgements

We are grateful to Dr Ireneusz Włodarczyk from Astronomical Observatory of the Chorzów Planetarium for very valuable discussion. This work was partly supported by the Polish Committee for Scientific Research (the KBN grant 4 T12E 039 28).

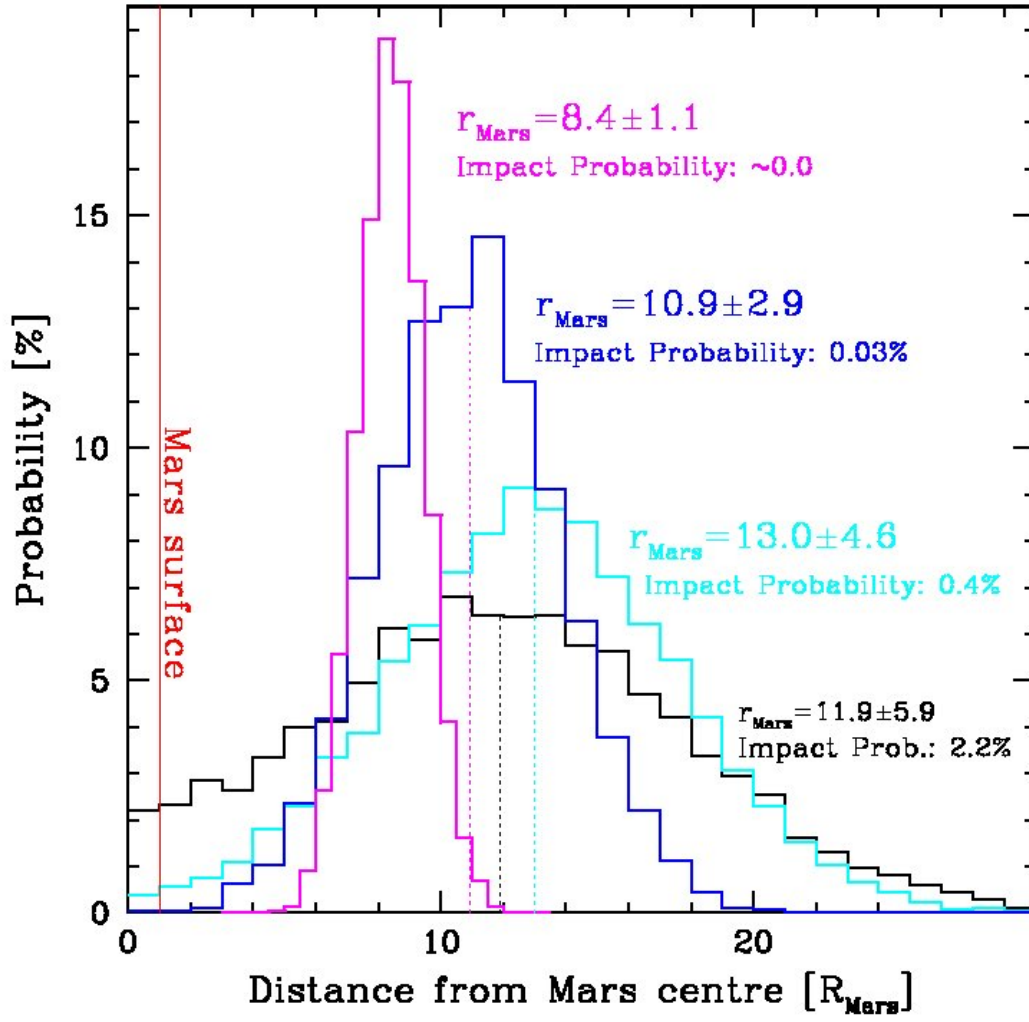


Figure 1: Distribution of the minimum distance of the asteroid 2007 WD₅ from the centre of Mars in 2008 01 30.5 derived for the samples of 10 000 cloned orbits. Black, cyan, blue and magenta distributions correspond to the solutions A, B, C and D, respectively.

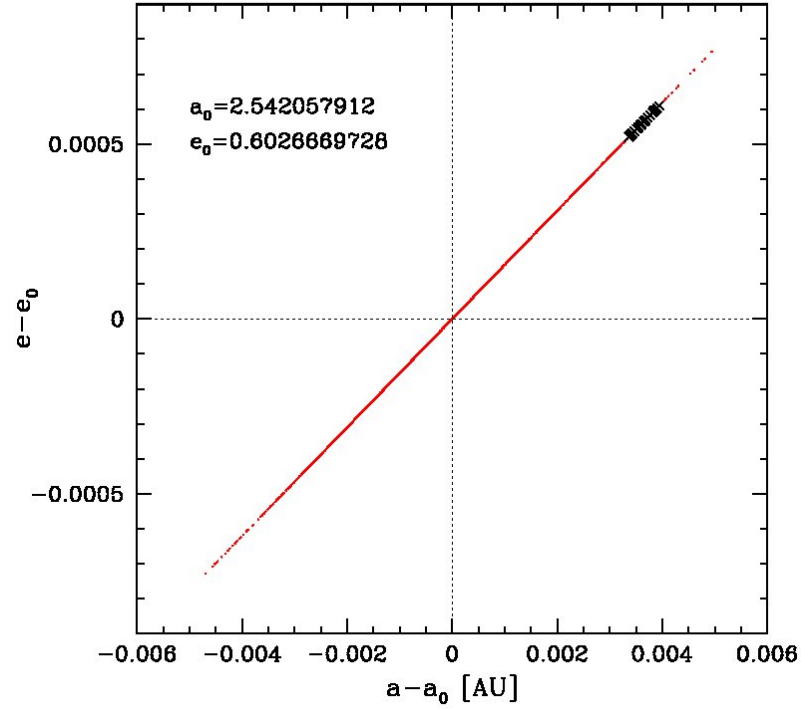
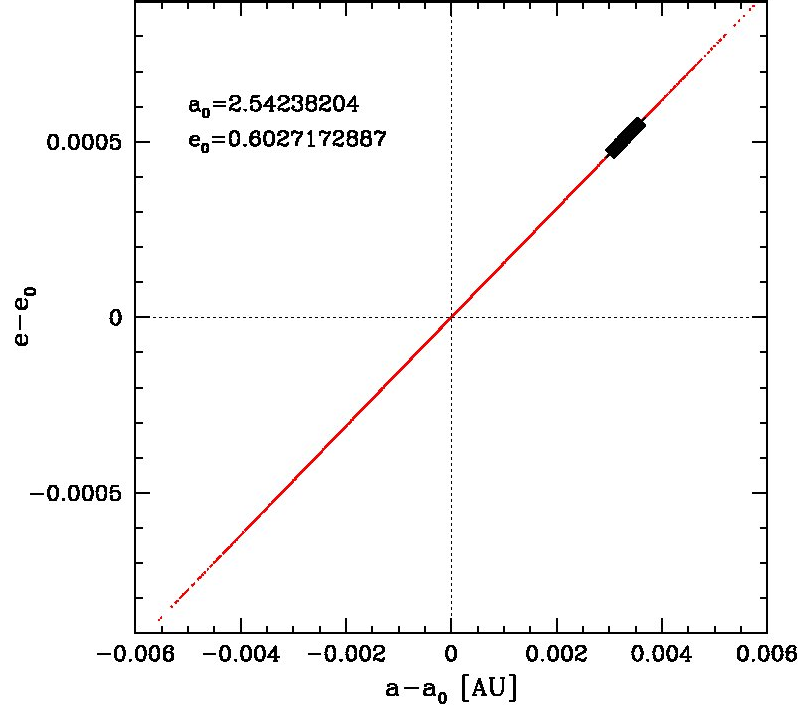


Figure 2: Projection onto the a - e plane in the 6-dimensional space of possible osculating orbits of 2007 WD₅ obtained for solution A (upper panel) and solution B (lower panel). Sample of 10 000 cloned orbits is given by red points, while the impact orbits are given as black crosses. The plot is centered on the values of semimajor axis, a_0 , and eccentricity, e_0 , of the respective nominal orbits (epoch: 2007 10 27).

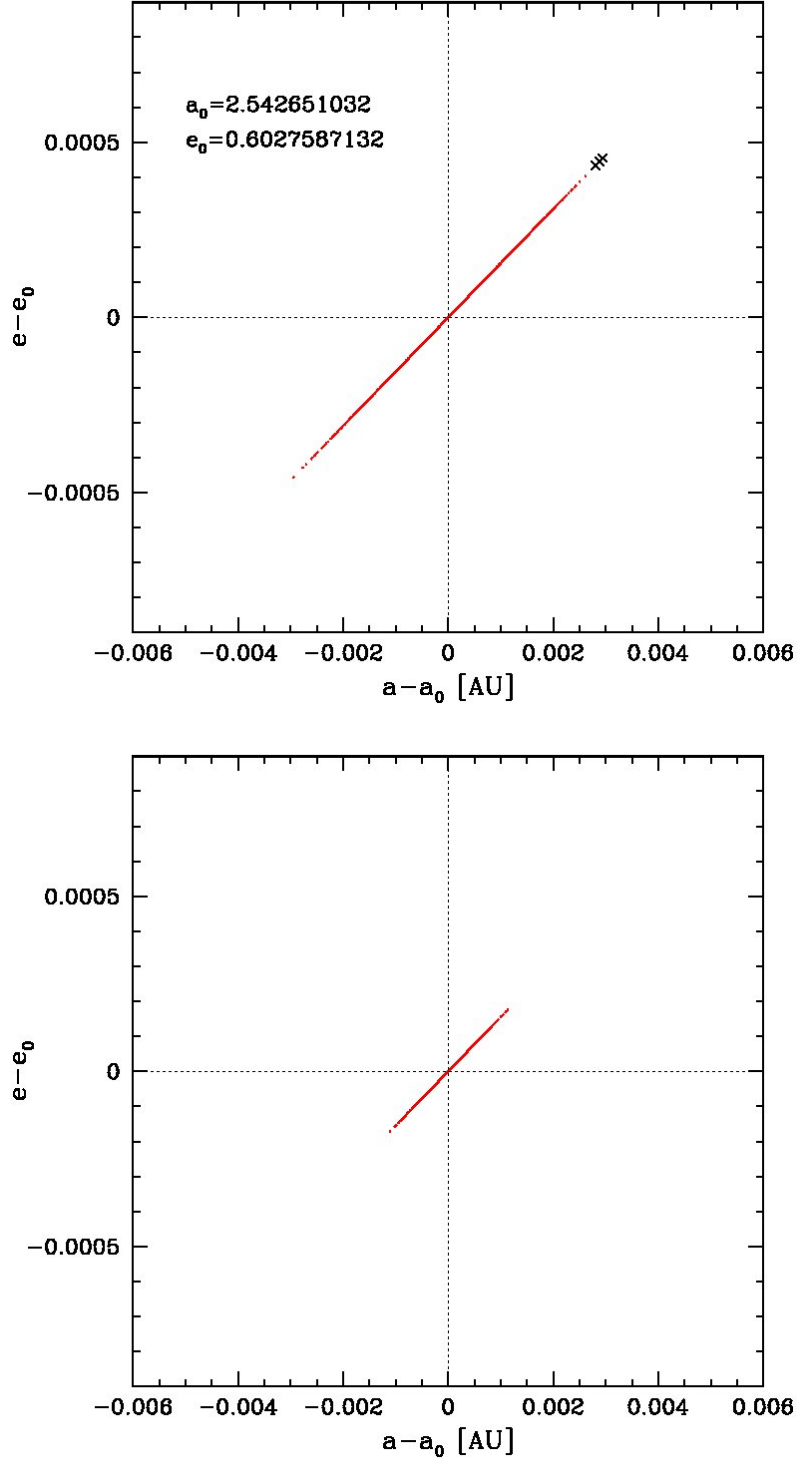


Figure 3: Projection onto the a - e plane in the 6-dimensional space of possible osculating orbits of 2007 WD₅ obtained for solution C (upper panel) and solution D (lower panel). Sample of 10 000 cloned orbits is given by red points, while the impact orbits are given as black crosses. The plots are centered on the values of semimajor axis, a_0 , and eccentricity, e_0 , of the respective nominal orbits (epoch: 2007 10 27).

Bibliography

Chesley S., and Chodas P., 2007, <http://neo.jpl.nasa.gov/news/news151.html>

Chesley S., Chodas P. and Yeomans, D., 2008, <http://neo.jpl.nasa.gov/news/news156.html>

NeoDys, 2008, <http://newton.dm.unipi.it/cgi-bin/neodys/neoibo?quicksearch:0;main>

Sitarski G., 1989, *Acta Astron.*, 39, 345.

Sitarski G., 1998, *Acta Astron.* 48, 547.

Sitarski G., 2002, *Acta Astron.*, 52, 471.

Yeomans D, Chodas P., and Chesley S., 2007, <http://neo.jpl.nasa.gov/news/news153.html>